SYSTEM AND METHOD FOR THE EFFICIENT CONTROL OF A RADIO COMMUNICATIONS NETWORK

TECHNICAL FIELD

This invention relates generally to the control of radio frequency communication systems, and more particularly, to a system and method of optimizing utilization of a single channel or frequency of such a communication system.

BACKGROUND OF THE INVENTION

Much work has been done to optimize the access of communications media where the use of a single communications channel must be shared by a large number of users. Common techniques include time-division multiple access (TDMA), polling, token passing, token rings, random access with no sensing, random access with sensing, slot reservation and many others. These techniques have been used over telephone lines, satellite channels, coaxial cables, bus architectures and various types of radio links such as packet radio, cellular telephone, meteor burst, troposcatter and others.

Each of these techniques has its own particular advantages and disadvantages. Any single approach will work well for the situation where the use fits the access method, but will not work as well where the traffic distribution is not optimum. In the field of mobile communications where the sites are not fixed, the traffic demands are irregular, and the link characteristics are dynamic and unpredictable.

In previous installations of mobile radio frequency (RF) communications, a carrier-sense multiple access (CSMA) system has been used. As a particular unit gets data to transmit, it listens to the channel, sometimes called a link, to be sure no other unit is already transmitting. If the link is busy, the unit waits a random amount of time, then listens again. This is repeated until the link is thought to be free, then the unit transmits its channel acquisition request to the destination unit. The CSMA system works well where only a few units have data to transmit at any given time.

In the CSMA system, there is a finite amount of time required to determine if the link is free, and once the unit begins a transmission sequence it can no longer determine if another unit is transmitting. Thus, when multiple units listen for a free link, there is a certain probability that at least two units will begin transmission at nearly the same time because both units determined that the link was free. This transmission collision usually causes both transmissions to be lost because the receiving units can not demodulate the data packets error free. Such collisions also occur when a unit cannot hear another unit that is transmitting and thus mistakenly believes a link is free.

In an RF environment, the transmit power is high enough to damage the receiver unless the receiver is disabled during transmission. Therefore, a unit cannot monitor its receiver during its own transmission to determine if any other unit has transmitted and caused a collision. Thus, classic CSMA collision detection (CSMA/CD) modes can not be used. As discussed in *Telecommunications Protocols and Design*, by Spragins, J.D., Hammond, J.A., and Pawlski, K., Addision-Westly Publishing, 1991, this limits the channel utilization to less than 0.5 of the available bandwidth. This means that 50% of the transmissions in this type of network are lost. As the number of users increases, the result is that even more transmissions are lost.

Another conventional technique to control communications over a single link is to reserve a time slot for each unit.

With the slotted reservations system, a base unit (not shown) sends a reservation data packet or list to all remote units (not shown). The reservation data packet tells the remote units when they can each transmit and how long each can transmit. However, the slotted reservation system is not always effective because it only works when all units in any given area can receive each other's transmissions error free to allow them each to determine which unit has the link reserved in the next time slot. Many collisions can still occur. In addition, the slot reservation data packet itself takes up additional transmission time as well, thus reducing the system efficiency. Furthermore, a slotted reservation system may be very inefficient because time slots are allotted for remote units that have no data to transmit. Thus, the link may be unused for a significant percent of time.

Therefore, it can be appreciated that there is a significant need for a system and method for efficiently controlling communication over a single link. The present invention provides this and other advantages as will become apparent through the following description and accompanying drawings.

SUMMARY OF THE INVENTION

The present invention is embodied in a system and method for the control of radio communications. The system comprises a plurality of remote radio units each having transmit and receive capability. Each of the remote units operates in a first mode to transmit a poll request signal to initiate communications and a second mode to transmit data. A base station also having transmit and receive capability receives a plurality of respective poll requests from the plurality of remote radio units and transmits a poll signal to at least some of the remote radio units. The poll signal includes a poll response sequence indicative of a particular time frame in which each of the remote radio units will respond to the poll signal. A poll detection unit in each of the remote radio units detects the poll signal. A control unit in each of the remote units controls transmission of the data in the particular time frame such that each of the remote radio units transmits data in the second mode in the time frame corresponding to the response sequence in the detected poll signal.

In a preferred embodiment, the first mode of operation is a carrier sense multiple access (CSMA) mode. The system further includes a carrier sense circuit in each of the plurality of remote radio units to detect the presence of the carrier frequency. Each of the remote radio units delays random length of time if the carrier sense circuit detects the presence of carrier frequency and permits transmission in the CSMA mode only when the carrier sense circuit does not detect the presence of the carrier frequency.

The system may also include a sequence list within the base station, with the sequence list containing data used to form the poll response sequence. The poll response signal from the remote radio units contains data indicative of the communications interval for each of the remote radio units. The poll detection unit receives the communications interval data and alters the sequence list accordingly such that a poll response sequence reflects the altered sequence list.

The poll request signal from the remote radio unit may contain data indicative of a communications interval for each of the remote radio units. The base station periodically transmits the poll signal and the poll sequence is altered in each of the periodically transmitted poll signals in response to the communication data interval for each of the plurality of remote radio units. The poll signal may also include first